MIPP- (FNAL-E907) Main Injector Particle Production Experiment Status and plans

Rajendran Raja

Report to the Fermilab PAC

28-March-2003

- Description of Experiment and goals
- Status and Schedule
  - Hardware systems
  - Software systems
  - Beam
- Status of finances in FY03

Brief Description of Experiment

- Approved November 2001
- Situated in Meson Center 7
- Uses 120GeV Main Injector Primary protons to produce secondary beams of $\pi^{\pm}$ $K^{\pm}$ $p^{\pm}$ from 5 GeV/c to 100 GeV/c to measure particle production cross sections of various nuclei including hydrogen.
- Using a TPC we measure momenta of ~all charged particles produced in the interaction and identify the charged particles in the final state using a combination of dE/dx, ToF, threshold Cherenkov and RICH technologies.
- Open Geometry- Lower systematics. TPC gives high statistics. Existing data poor quality.

Physics Interest

- Particle Physics-To acquire unbiased high statistics data with complete particle id coverage for hadron interactions.
  - » Study non-perturbative QCD hadron dynamics, scaling laws of particle production
  - » Investigate light meson spectroscopy
- Nuclear Physics
  - » Investigate strangeness production in nuclei- RHIC connection
  - » Nuclear scaling
  - » Propagation of flavor through nuclei
- Service Measurements
  - » Atmospheric neutrinos – Cross sections of protons and pions on Nitrogen from 5 GeV- 120 GeV
  - » Improve shower models in MARS, Geant4
  - » Make measurements of production of pions for neutrino factory/muon collider targets
  - » Proton Radiography– Stockpile Stewardship- National Security
  - » MINOS target measurements – pion production measurements to control the near/far systematics
- HARP at CERN went from 2-15GeV/c incoming pion and proton beam momenta. MIPP will go from 5-100 GeV/c for 6 beam species $\pi^{\pm}$ $K^{\pm}$ $p^{\pm}$

E907collaboration list

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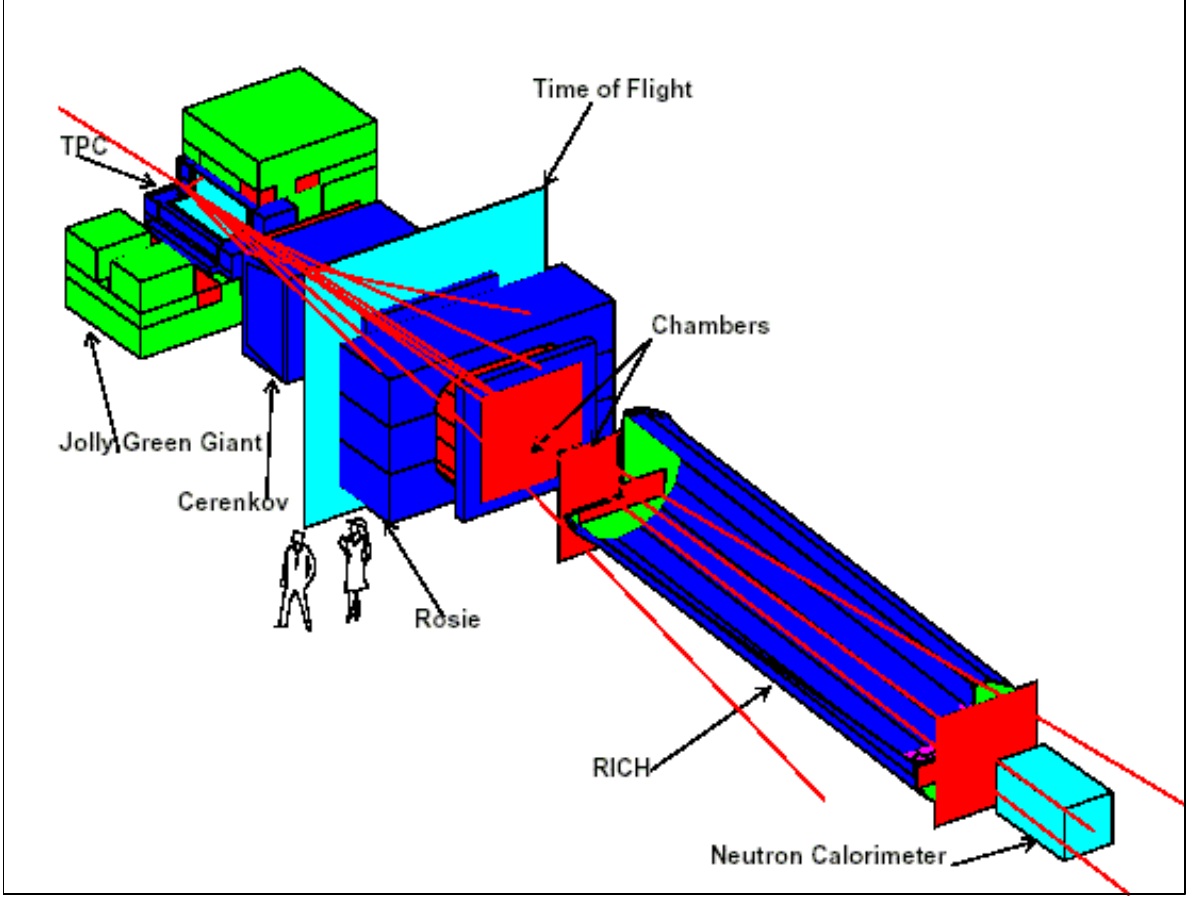
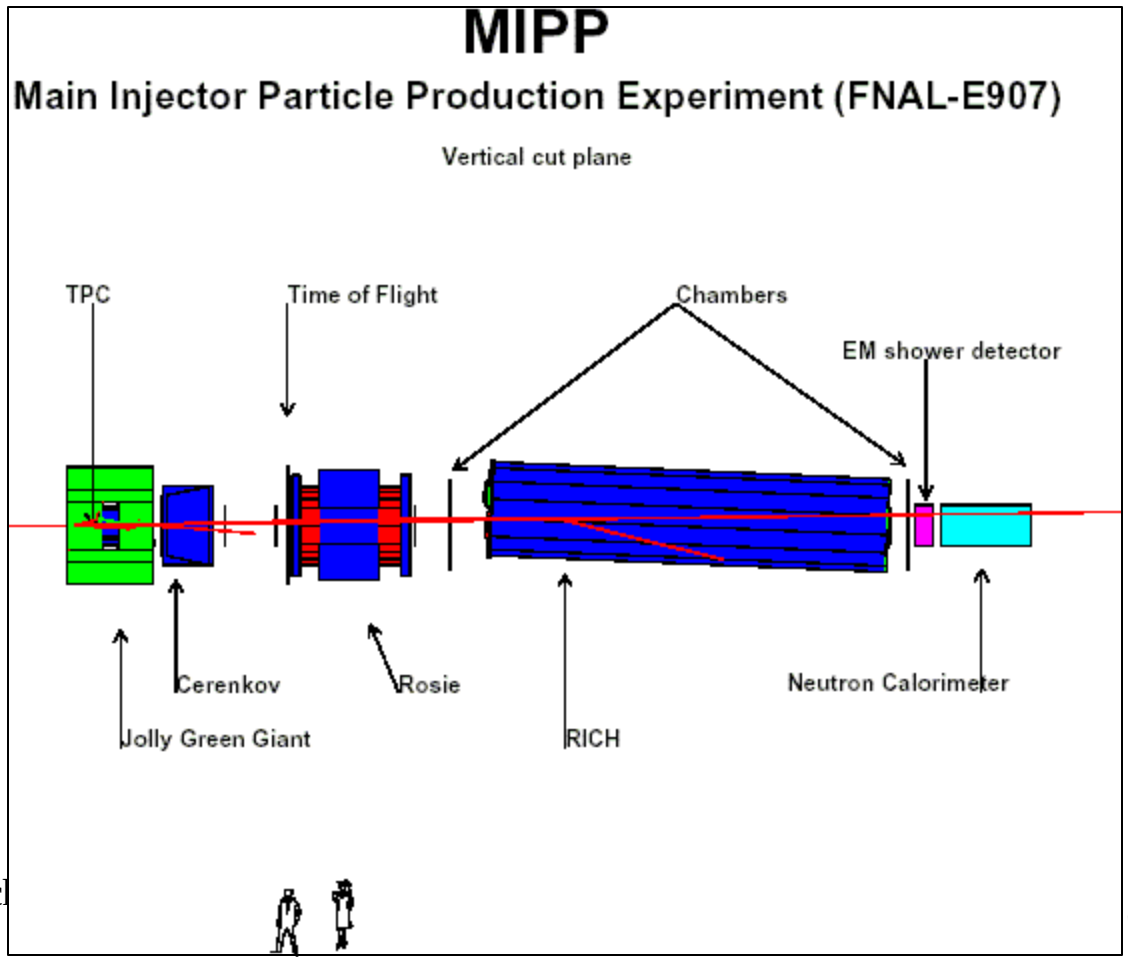

Time of Flight
TPC
Chambers
Jolly Green Giant
Cerenkov
Rosie
RICH
Neutron Calorimeter


MIPP
Main Injector Particle Production Experiment (FNAL-E907)
Vertical cut plane
TPC
Time of Flight
Chambers
EM shower detector
Cerenkov
Rosie
RICH
Neutron Calorimeter
Jolly Green Giant

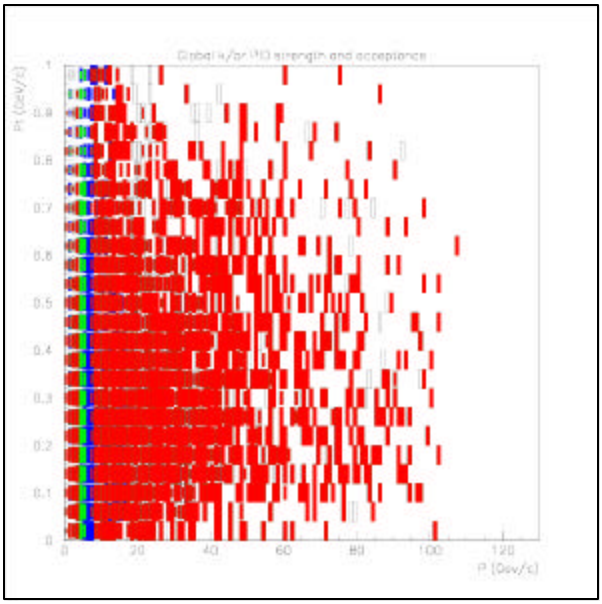
MIPP Particle ID capabilities

K/Proton separation analysis using all systems.

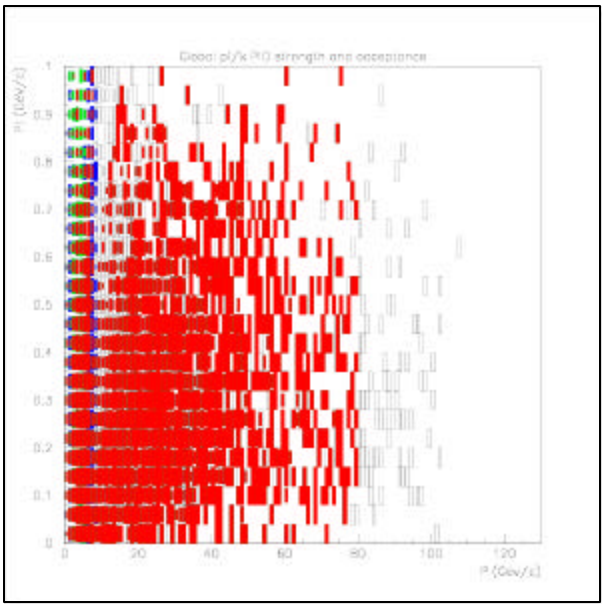
- Red = 3σ or better.
- 3σ < Green < 2σ
- 2σ < Blue < 1σ

0σ < White < 1σ

K/P separation



π/K separation



Situation at PAC approval (Nov 2001)

- We had cleaned up the previous experiment in MC7 Hyper-CP.
- We had designed and constructed iron struts to support the weight of the magnets Jolly Green Giant and Rosie and installed it in M-Bottom.
- We had installed a 1' high concrete platform in MC7 to support the magnets.
- We had fixed the Jolly Green Giant coil

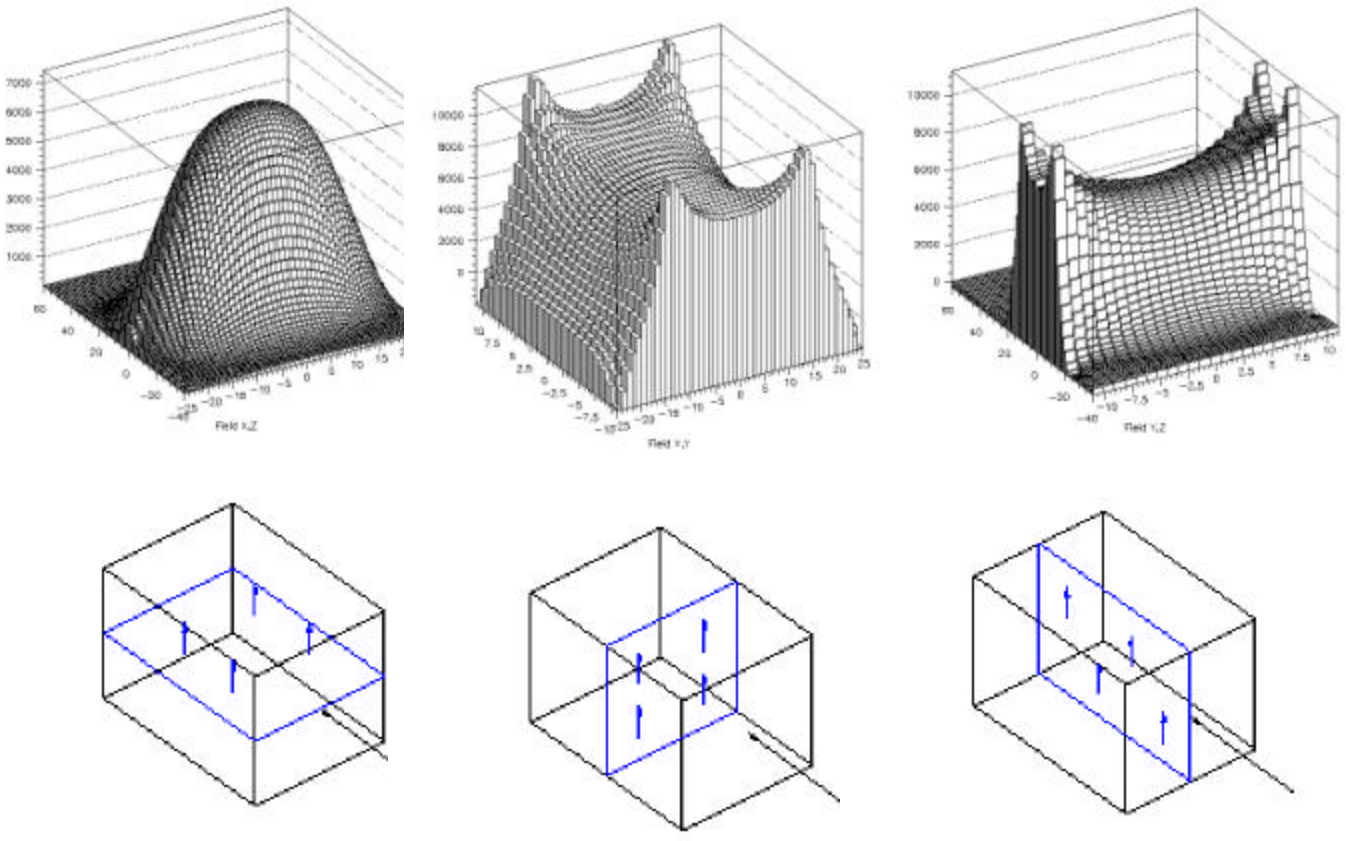
Status of MIPP Now- Collision Hall

Status of MIPP Now- Collision Hall

Ziptrack of magnets complete

- We resurrected the Ziptrack system
  - » Software recovered by sending out crashed disk to Calfornia.
  - » Missing Hall probe cart re-made. Measured B_x, B_y, B_z in a 2” cube grid of points for both JGG and ROSIE over full aperture.
  - » Ziptrack now available for CKM and BTeV.

JGG B_{y} component in projections y=0, z=0 and x=0



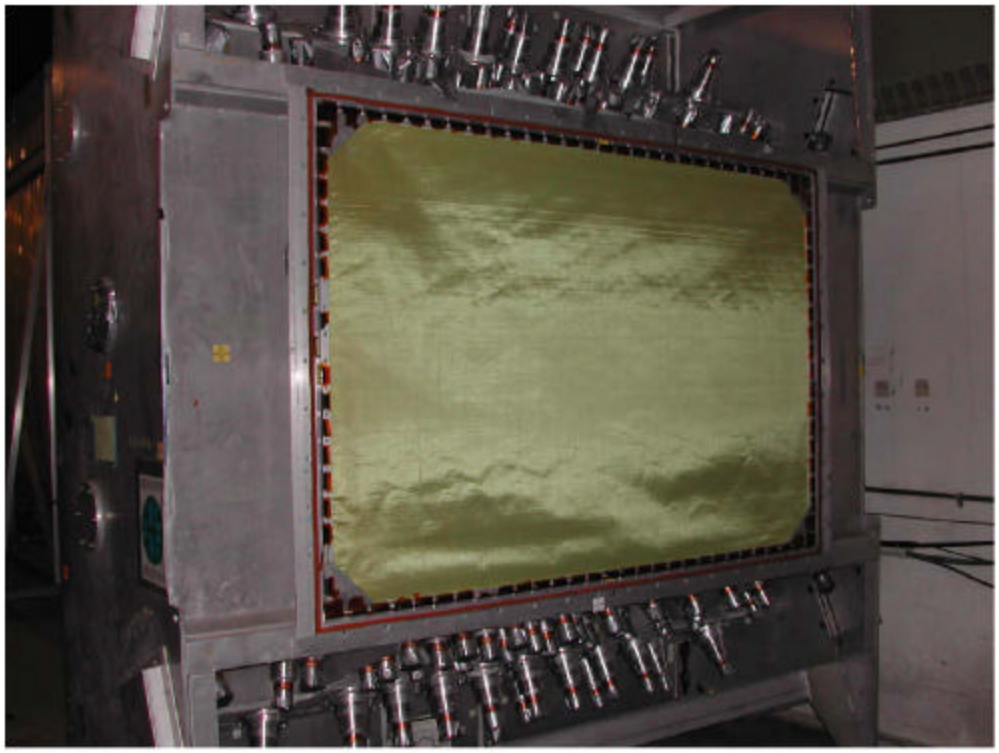
Installation schedule

- MIPP running time June 2003- Summer Shutdown 2005 (~ two years) (Jeff Appel)
- Experiment hopes to be ready by June 2003

	Fermilab E907 MIPP			
	Installation Schedule			
WBS	Task Name	Duration	Start	Finish
5.2.4	Beam Cerenkov	37 days	4/7/03	5/27/03
5.5	Cerenkov	52 days	3/27/03	6/6/03
5.7.1	Target Wheel	35 days	4/7/03	5/23/03
5.8.5	TPC Installation	33 days	4/7/03	5/21/03
5.1	Time of Flight	99 days	4/14/03	8/28/03
5.11	RICH	54 days	3/20/03	6/3/03
5.12	Drift Chambers	65 days	3/20/03	6/18/03
5.13	Hadron Calorimeter	52 days	4/7/03	6/17/03
5.16	EM Calorimeter	67 days	3/20/03	6/20/03
5.15	DAQ	30 days	5/5/03	6/13/03

- See above chart in detail at http://ppd.fnal.gov/experiments/e907/Project/E907_v2.05_Install.det.pdf

MIPP Cherenkov

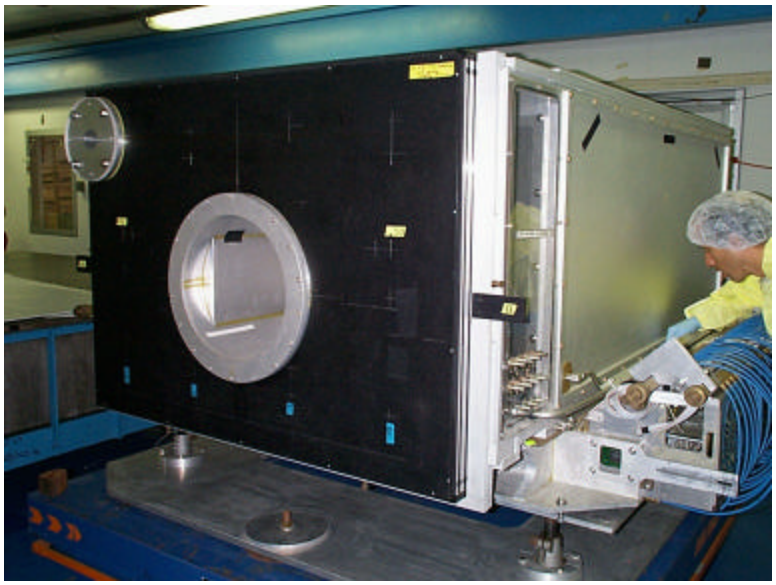


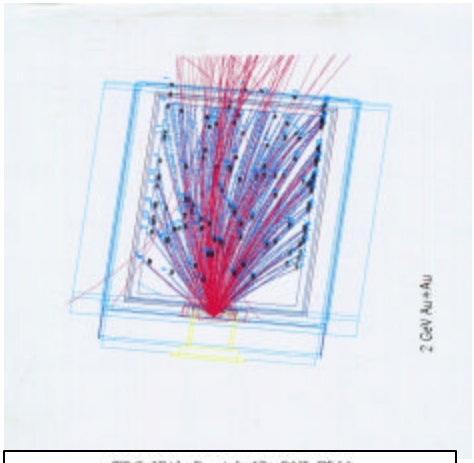
- Status-Install and align mirrors 3/27 – 3/28/03
- PMT testing 4/25 – 5/2/03
- Cabling 5/26 – 5/27/03
- Gas (C4F10) 6/2 -- 6/6/03
- Currently box is in MC7 in its position.

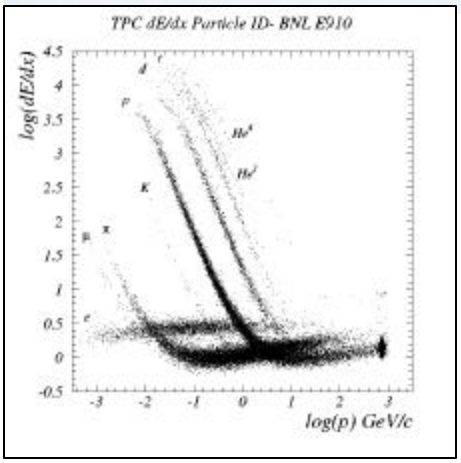
TPC installation

- TPC in clean room in MC7.

5.9.5	**TPC Installation 33 days 4/7/03 -- 5/21/03**
5.9.5.1	TPC Repair BNC 2 days 4/7/03 4/8/03
5.9.5.2	TPC Place on Cart 1 day 4/9/03 4/9/03
5.9.5.3	TPC DC Rack Installation 3 days 5/5/03 5/7/03
5.9.5.4	TPC Gas Rack Refurbishment 5 days 4/7/03 4/11/03
5.9.5.5	TPC Gas Rack Installation 3 days 5/8/03 5/12/03
5.9.5.6	TPC Mixing Rack Installation 7 days 5/13/03 5/21/03
5.9.5.7	TPC Cable Installation 3 days 5/8/03 5/12/03





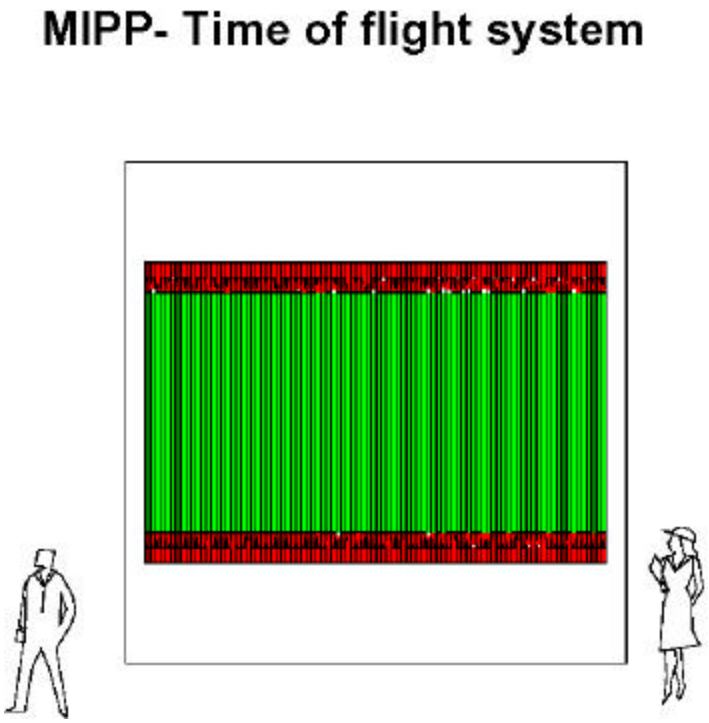


Time of Flight

- Time of flight ($220K) being financed by a loan from University of South Carolina with a promise from Livermore to pay it back in the next few years.

5.10 Time-of-Flight (TOF)	**99 days**	**4/14/03 8/28/03**
5.10.1 TOF Module Frame Design	10 days	4/14/03 4/25/03
5.10.2 TOF Module Fabrication	4 mons	4/28/03 8/15/03
5.10.3 TOF Module Installation	5 days	8/18/03 8/22/03

Somewhat delayed due to difficulties in getting financing.
5cmx 5cm square scintillator bars in Rosie aperture, 10cmx10cm outside. ~ 150ps resolution.



Ring Imaging Cherenkov

- Selex RICH-We acquired all phototubes from the Russians- total of ~ 3000 phototubes
- Completely redesigned the front end electronics– 5 VME boards and ~100 (32 channel) readout boards. VME boards complete.
- 25 (32 channel boards) were delivered to Harvard for testing this week. They look OK. Remaining boards expected soon.

RICH Schedule

5.11 Ring Imaging Cherenkov (RICH) 54 days 3/20/03 6/3/03

5.11.6 RICH Install Support Equipment 10 days 5/19/03 5/30/03

5.11.7 RICH Gas Clean and Fill 2 days 6/2/03 6/3/03

5.11.10 RICH Front End Electronics Fab ~31.5 days 3/20/03 5/2/03

5.11.11 RICH Electronics Installation 2 days 5/2/03 5/6/03

Calorimeters

Hadron Calorimeter schedule

5.13 Hadron Calorimeter (HCAL) 52 days 4/7/03 6/17/03

5.13.2 HCAL Refurbishment 15 days 4/7/03 4/25/03

5.13.3 HCAL Installation 3 days 6/11/03 6/13/03

5.13.4 HCAL Gas Distribution 3 days 6/13/03 6/17/03

EM calorimeter schedule

We are building a lead sheet- gas tube EM calorimeter.

5.16 Electromagnetic Calorimeter 67 days 3/20/03 6/20/03

5.16.2 ECAL Fabrication 20 days 3/20/03 4/16/03

5.16.3 ECAL Installation 5 days 6/16/03 6/20/03

Wire Chambers

- Refurbishing E690 drift chambers as well as U-Iowa large PWC's from last used by University of Iowa in Selex.

5.12 Drift Chambers (DC) 65 days 3/20/03 6/18/03

5.12.5 DC Testing 62 days 3/20/03 6/13/03

5.12.5.1 DC Test Stand Electronics Ch 7 days 3/20/03 3/28/03

5.12.5.2 DC Test Remaining Electronic 30 days 3/31/03 5/9/03

5.12.5.3 DC4 Testing 25 days 3/31/03 5/2/03

5.12.5.4 DC1 Testing 10 days 5/5/03 5/16/03

5.12.5.5 DC2 Testing 10 days 5/19/03 5/30/03

5.12.5.6 DC3 Testing 10 days 6/2/03 6/13/03

5.12.4 DC Installation 33 days 5/5/03 6/18/03

5.12.4.1 DC4 Installation 5 days 5/5/03 5/9/03

5.12.4.2 DC1 Installation 3 days 5/19/03 5/21/03

5.12.4.3 DC2 Installation 3 days 6/2/03 6/4/03

5.12.4.4 DC3 Installation 3 days 6/16/03 6/18/03

5.12.4.5 DC5 Installation 5 days 5/12/03 5/16/03

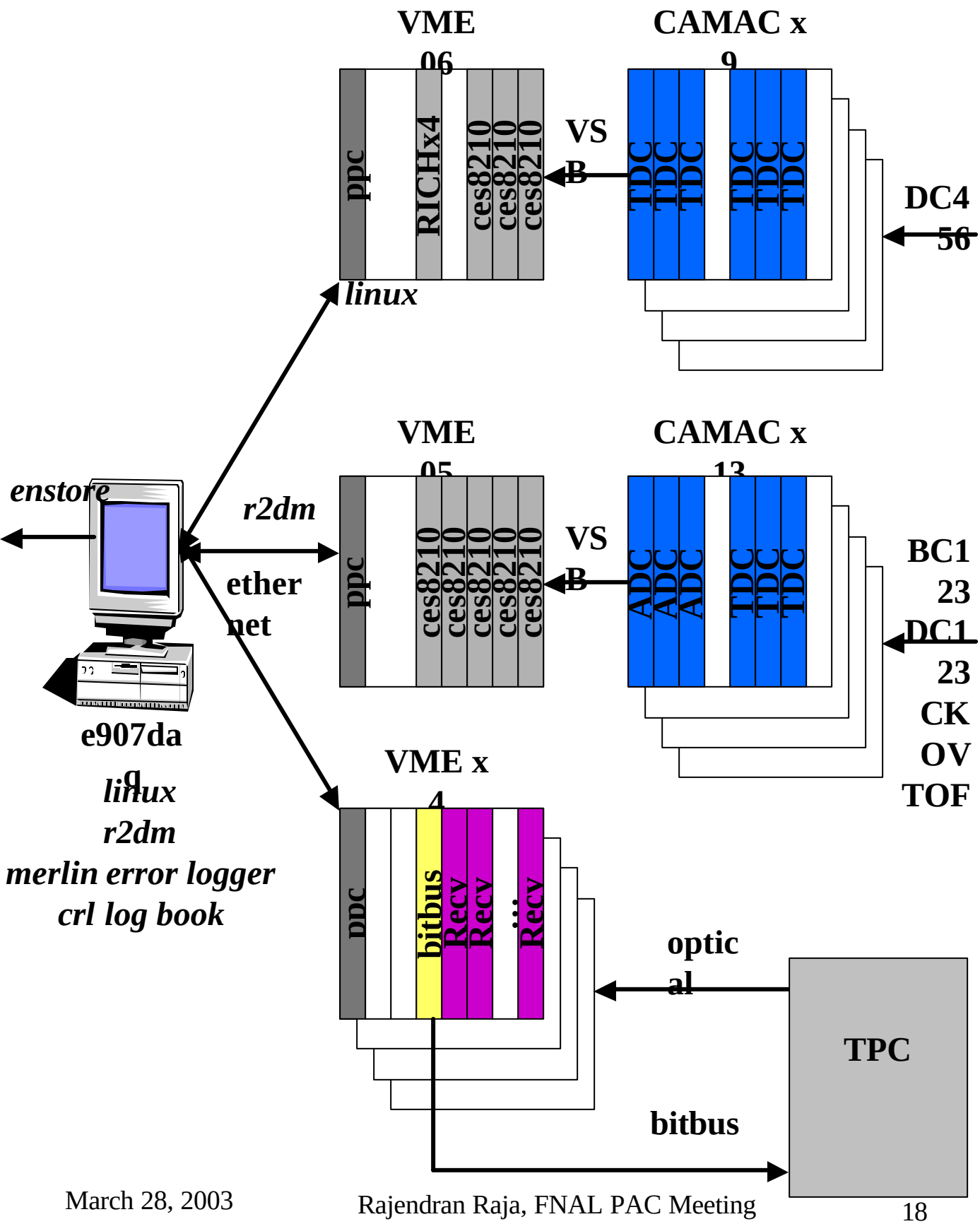
5.12.4.6 DC6 Installation 5 days 6/4/03 6/10/03

5.12.6 DC Gas Systems 44 days 4/14/03 6/12/03

5.12.6.1 DC Gas Mixing Systems 14 days 4/14/03 5/1/03

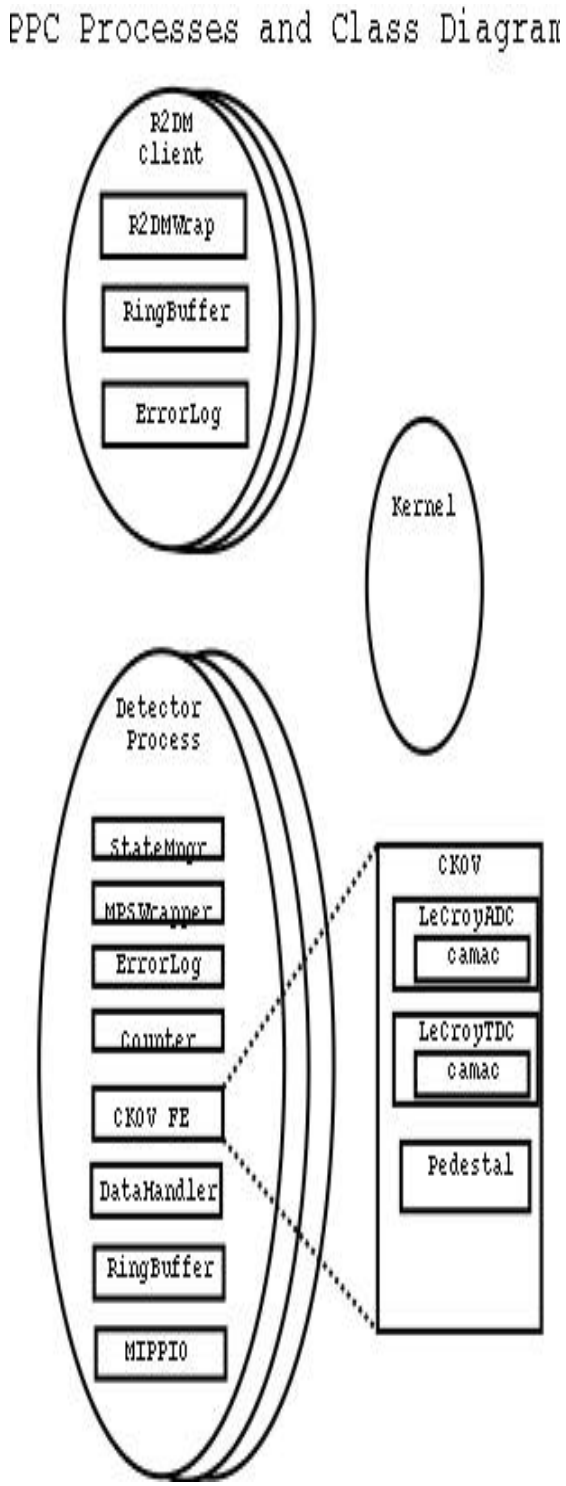
5.12.6.2 DC Gas Distribution 30 days 5/2/03 6/12/03

MIPP DAQ Hardware



MIPP DAQ Software

- Fully modular
  - » C/C++
  - » Linux on ppc
  - » Sample Detector Class
- FNAL ODE Tools
  - » Java Run Control (Bruce Greenway)
  - » E907R2DM (Luciano Piccoli)
  - » Elvin message passer (Luciano Piccoli)
  - » CES8210 libs (Dave Slimmer)
- Recent Progress
  - » New linux kernel (2.2.12) & filesystem
  - » Interrupt scheme implemented
  - » CKOV class (base camac class)
  - » Run Control near completion
  - » All elements implemented in LLNL test stand



MIPP DAQ Schedule

- LLNL test stand work ~6 weeks
  - » Camac
    - Full run control
    - Add hardware interrupts
    - Database communication
  - » TPC
    - Bitbus control class
    - Dsp readout/stick testing
    - Data processor
- Harvard test stand work ~4 weeks
    - Electronics test
    - Rich daq class

- ODE schedule
  - » Close out development
  - » Some Run Control development remains
  - » Entering supporting role for other packages

- Mipp Comission (April-June)
  - Add second linux box (from LLNL)
  - RedHat OS update
  - New detector classes : inherit Camac
  - Test multi-detector readout
  - Test connection to enstore

- Linux on ppc observations
  - No problems with our “linux” decision
  - All ppc’s have been ordered, will arrive soon

5.15 DAQ Commissioning 30 days 5/5/03 6/13/03

5.15.3 DAQ Slow Controls 30 days 5/5/03 6/13/03

Monte Carlo

- Geant3.21 based data driven Geometry. Details can be found at http://ppd.fnal.gov/experiments/e907/MC/e907mc.htm
- Have used it to stud acceptances, resolutions and ToF design.
- Work to be done- Digitize wire chambers, Implement calorimeters and beam Cherenkovs.

Offline Software

Monte Carlo Geometry transported to ROOT.

Offline C++, ROOT IO. MIPP has benefited enormously from the ability to use the same geometrical data-base in Monte Carlo and Reconstruction. Result of discussions during ACAT2000 conference held at Fermilab.

MIPP Offline Software summary

C++ / ROOT based

'ROOT' is CERNLIB/PAW replacement
- Provides "one stop shopping" for i/o, physics, geometry, graphics, histogram, analysis...
- Minimizes number of packages required
- Allows for rapid development

Basic Elements of MIPP Software are in place:
- Data format and Input/Output
- Database
- Geometry
- Monte Carlo "truth" access
- Event Display

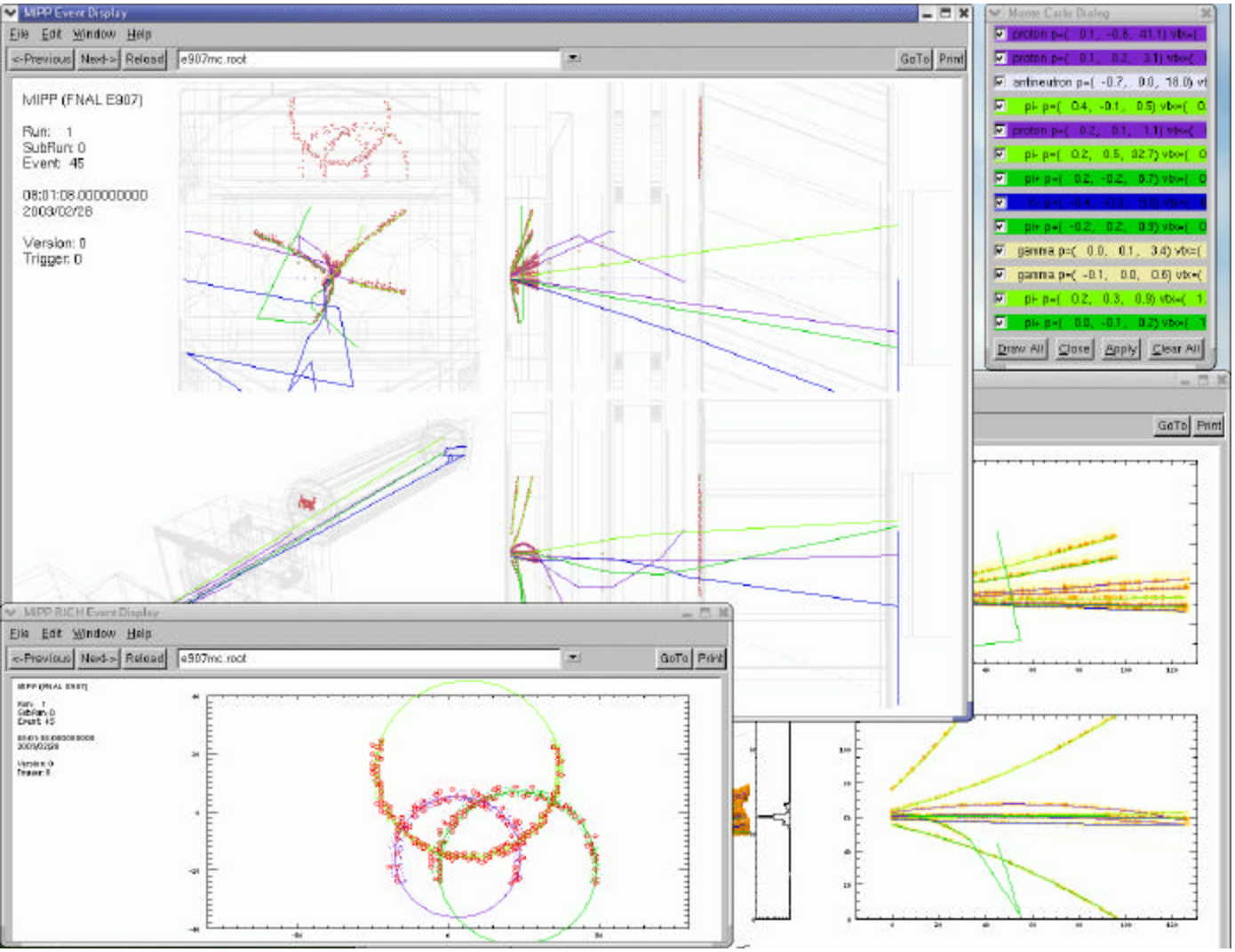
Work underway to connect online and offline
- Online data handling
- Online data monitoring

Work underway on reconstruction software

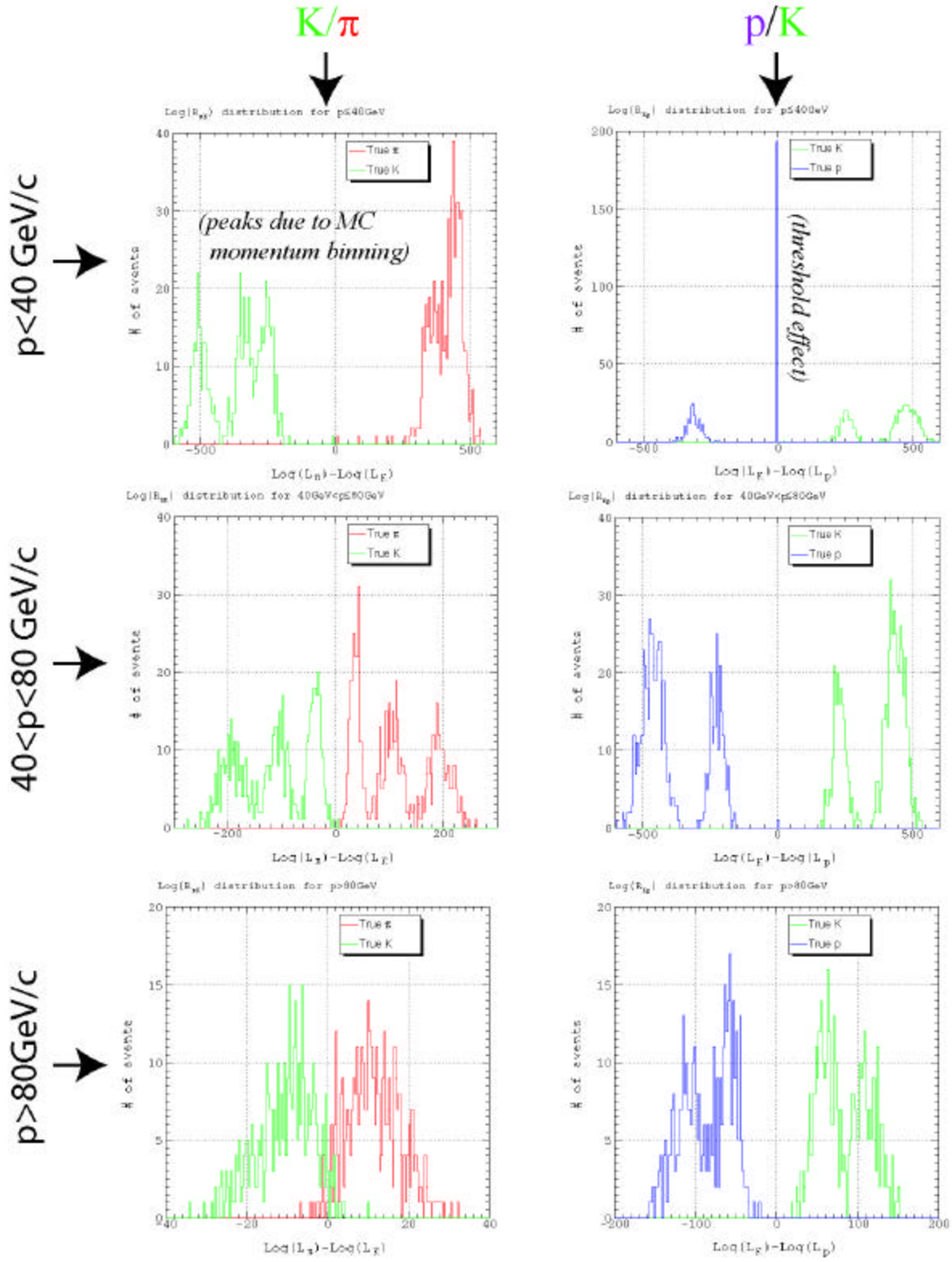
Detector	*Simulation*	*Reconstruction Status*
TPC	*Done*	*Track finding, Track fitting (requires Bfield), dEdx*
DC's	*in progress*	
CKOV	*in progress*	
TOF	*in progress*	
RICH	*Done*	*Radii fits for π/K/p:~Done*
NCAL/HCAL	*in progress*	

Expect to have online/offline connections ready by end of May
Expect to have first pass at reconstruction by June

Event Display

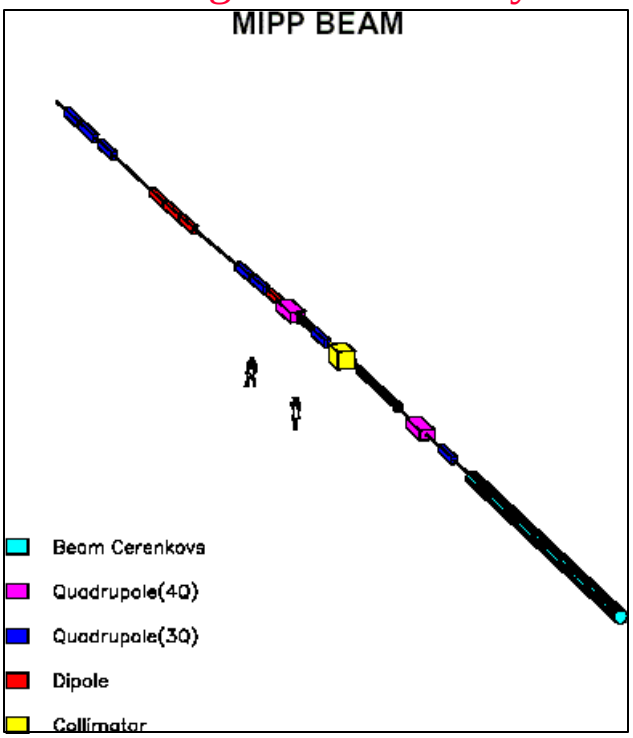


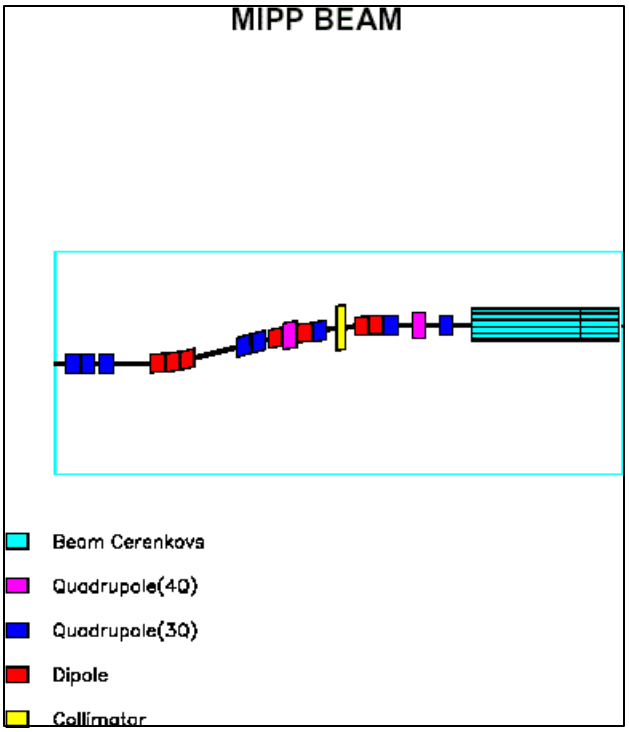
RICH Particle ID Fits



MIPP Secondary Beam

- MC7 Hyper CP beam line removed. Target pile cleaned up.
- Beamline group of MIPP collaborators and Switchyard 120 personnel. Have examined 4 beam designs (using TRANSPORT, MAD and MARS (calculates showering backgrounds). Have decided on a design. Have in hand refurbished EPB dipoles needed. The Quadrupoles needs have also been identified. They need to be tested at the Magnet Test factory.





MIPP secondary beamline

Primary Proton Budget

Table 5 Primary beam rates, secondary beam rates and event yields for a positive secondary beam

p GeV/c	Primary p/spill	p Hz	K Hz	π Hz	Total Hz	p events	K events	π events	total events
5	9.66E+09	7404	1583	116013	125000	1000000	340391	1000000	2340391
15	2.10E+09	16968	4651	74886	96505	10000000	10000001	1000000	3000000
25	1.08E+09	28457	4651	60948	94055	10000000	10000001	1000000	3000000
30	8.92E+08	36365	4651	56926	97942	10000000	10000001	1000000	3000000
40	7.19E+08	59890	4651	50114	114655	10000000	10000001	1000000	3000000
50	5.76E+08	84327	3854	36820	125000	1000000	828519	1000000	2828519
60	4.37E+08	100367	2601	22032	125000	1000000	559231	1000000	2559231
70	3.43E+08	111720	1575	11705	125000	1000000	338524	1000000	2338524
80	2.86E+08	118639	861	5500	125000	1000000	185184	1000000	2185184
90	2.67E+08	122354	422	2224	125000	1000000	90714	645042	1735755
100	3.07E+08	124115	176	709	125000	1000000	37818	205646	1243464
110	5.82E+08	124819	51	130	125000	1000000	11007	37783	1048790

Table 6 Primary beam rates, secondary beam rates and event yields for a negaitive secondary beam

p GeV/c	Primary p/spill	pbar Hz	K Hz	π Hz	Total Hz	pbar events	K events	π events	total events
5	1.49E+10	77471	726	115527	125000	1000000	4313911000000		2431391
15	3.78E+09	41924	651	99287	108130	10000001	0000001000000		3000000
25	2.77E+09	26134	651	82580	89843	10000001	0000001000000		3000000
30	2.73E+09	21924	651	79822	86666	10000001	0000001000000		3000000
40	3.94E+09	20005	683	101496	109179	10000001	0000001000000		3000000
50	5.73E+09	15205	626	117855	125000	85862110	0000001000000		2858621
60	8.24E+09	9104	449	119641	125000	51405610	0000001000000		2514056
70	1.38E+10	4813	241	121278	125000	271690	8103161000000		2082006
80	2.80E+10	2152	145	122640	125000	121342	5363021000000		1657644
90	7.62E+10	741	237	123688	125000	41906	3093401000000		1351246
100	2.00E+11	9	327	72576	72913	5322	818391000000		1087161
110	2.00E+11	0	6	4867	4873	25	13941000000		1001420

MIPP secondary beamline

Primary Proton Budget

Table 1 Physics request and proton needs

Target	Physics	Data Points	Primary proton Average Intensity/spill	Total number of Primary Protons
Numi 1	MINOS	3.3	125000	2.06E+10
NUMI 2	MINOS	3.3	125000	2.06E+10
H2	Scaling	6	9.76E+09	2.93E+15
N2	Atmospheric ν	4	9.76E+09	1.95E+15
Be	pA	2	9.76E+09	9.76E+14
Be	Survey	1	9.76E+09	4.88E+14
C	Survey	1	9.76E+09	4.88E+14
Cu	pA	2	9.76E+09	9.76E+14
Cu	Survey	1	9.76E+09	4.88E+14
Pb	pA	2	9.76E+09	9.76E+14
Pb	Survey	1	9.76E+09	4.88E+14
Total		26.6		9.76E+15

Total number of spills 1330000

Number of spills/minute 3

Total time for expt 308 days No Pi factor

Double slow spill will help considerably.

- Design shielding around Primary target and collimator.
- Install. It is possible to have this done by June 2003.
- Beamline Cherenkovs- All mirrors resurfaced.

5.2.4 BCKOV Fabrication 37 days 4/7/03 5/27/03

5.2.4.1 BCKOV Flange Fabrication 4 wks 4/7/03 5/2/03

5.2.4.2 BCKOV Install Support Blocks 5 days 5/5/03 5/9/03

5.2.4.3 BCKOV Install Heads 2 days 5/12/03 5/13/03

5.2.4.4 BCKOV Install Pipes 10 days 5/14/03 5/27/03

5.2.4.5 BCKOV Install Gas System 10 days 5/14/03 5/27/03

5.2.4.6 BCKOV Install Mirror Controls 2 days 5/14/03 5/15/03

Beamline chambers all functional.

Financial status

- In FY2002, we received ~$530K from Livermore through an ICO. Fermilab charged overhead on it. PPD made up for the overhead by making available engineering effort for ~$150K.
- This year, FY2003 we expected the same amount from Livermore. Unfortunately, $165K from last year's budget did not get charged to Livermore by October 1, 2002, despite our repeated urging of both accounting departments that this should happen. So $165K got charged to this year's ICO. Also, we are not being given a break for the overhead.
- We need help at this point to complete installation. Efforts are being made at both labs to ameliorate this situation. We also need to get the Liquid Hydrogen target work started. This has a long lead time. Liquid Hydrogen data is essential in understanding MIPP systematics, as well as for dynamical studies.
- Our failure will not contribute significantly to the success of other experiments, since the sums being talked about are small on the scale of the big experiments.

Conclusions

- MIPP is able to obtain QCD data of unprecedented accuracy and information that will benefit a number of causes.
- MIPP needs some “extra” support from Fermilab and Livermore to make sure that we do not squander the beam time window available to us.